

# Principles of Planetary Rover Telecommunications

Rovers on extraterrestrial planets, moons and small bodies not only require telecommunications with Earth for command and telemetry, The rover telecommunications system can frequently be used for rover navigation as well. This paper briefly reviews past planetary rover telecommunications systems and studies of telecommunications for future planetary rovers. It then presents general principles of Direct-To-Earth (DTE) links with the Deep Space Network (DSN), space relay links, and ground relay links. It is intended to provide planetary rover designers with the information they need to identify their telecommunications options and to select the option best suited to their mission.

The basic telecommunications link equation has a number of implications for each type of planetary rover telecommunications link. This paper reviews the telecommunications link equation and draws several conclusions from it pertinent to planetary rovers. The paper reviews planetary rover radio navigation techniques and provides guidance on frequency selection and system design.

The paper shows that the DSN can receive telemetry directly from rovers with omnidirectional antennas at distances appropriate, the maximum range of Mars from Earth. As Mars approaches this range, however, a relatively high power (~10 W) is required and only very low data rates can be supported. DTE links at much higher ranges and data rates can be supported through the use of steered mobile antennas. The paper reviews mobile satellite antenna technology applicable to planetary rovers.

By dramatically decreasing communications range, telecommunications relays near planetary rovers can send and receive large amounts of data to and from rovers and relay this data to and from Earth. Communications relay packages on future U.S. Mars orbiters will relay communications between the DSN and Mars landers and rovers; a companion paper, "Telecommunications for Mars Rovers and Robotic Missions," characterizes these packages. This paper reviews general relay link design principles applicable to rover missions at other planetary bodies.

In some cases, land-based relays are preferred. The paper considers both ground wave- and RF-based land relays, and presents general design principles regarding these techniques.

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